

CIFE Publication Series No. PLT/107/2026



## Breeding Technologies of Ornamental Fishes

**Paramita Banerjee Sawant  
Debajit Sharma  
Gouranga Biswas  
Udipta Roy**

**Division of Aquaculture  
ICAR-Central Institute of Fisheries Education, Mumbai**

## **Introduction**

Breeding of ornamental fishes is an important component in ornamental fisheries sector, offering significant opportunities for employment, income and entrepreneurship particularly for small and marginal farmers. Commercially important ornamental fishes such as Oscar, discus, Killifishes, freshwater sharks and crustaceans (Shrimps) are highly valued in domestic and international market due to their attractive coloration, diverse body shapes, and peaceful behavior. With increasing urbanization, rising aesthetic awareness, and expansion of the aquarium hobby, the demand for quality ornamental fish seed has increased substantially.

The ornamental fish breeding in controlled conditions ensures continuous supply of healthy, uniform and disease free seeds which reduces dependence on wild stock, minimizing pressure on natural ecosystem. Broodstock management, water quality management and suitable nutrition are the key for successful breeding in captivity which ensures quality seed. Proper knowledge on fish handling, optimized reproduction methods and larval rearing skills is essential for success in breeding and sustainable development of ornamental fisheries conserving the biodiversity.

## 1. Breeding of Oscar fish (*Astronotus* spp.)



### 1.1 Origin and varieties

The Oscar (*Astronotus ocellatus*) is a freshwater cichlid native to the Amazon basin of South America, mainly found in Brazil, Peru, and Colombia. It inhabits warm, slow-moving waters with dense vegetation and submerged structures. The species is hardy and adaptable, making it popular in the ornamental aquarium trade, though introduced populations now exist in countries such as China, Australia, and the USA. Oscar fish are large and robust, growing up to 30 cm in length, weighing about 1.5 kg, and living 10-15 years under proper care. Common varieties include tiger, copper, albino, mango, super red, and red chilli oscar.

### 1.2 Broodstock conditioning and nutritional requirements

Spawning in Oscar fish can be induced by preparing a dedicated breeding tank with slightly elevated water temperature and enhanced dissolved oxygen levels. Broodstock should be fed high-quality pellets supplemented with fresh or frozen feeds, while juveniles require a high-protein diet; a crude protein level of at least 50% has been recommended (Khade et al., 2018). Dietary inclusion of live or frozen gammarus (25%) and bloodworms (25%) has shown to enhance skin pigmentation (Taati, 2025). Additionally, supplementation with spirulina (55 g kg<sup>-1</sup> feed), probiotics and prebiotics (*Lactococcus lactis*, *Bacillus subtilis*, xylooligosaccharides), and phytogetic such as garlic (10 g kg<sup>-1</sup> feed) positively influences growth and body coloration (Saghaei et al., 2015; Mohammadiazarm et al., 2021).

### 1.3 Sexual dimorphism

Oscar fishes are generally sexually monomorphic, with males and females appearing similar, particularly during early life stages. Ideal age for maturation and breeding of the fish is 12-16 months. Subtle sexual dimorphism may be observed in adults: males often grow faster and attain a larger size, and may display slightly more intense coloration or more prominent ocelli near the dorsal fin. The most reliable method for sex differentiation is examination of the genital papilla during the breeding period; males possess a small, pointed, V-shaped papilla, whereas females exhibit a larger, rounded, and blunt papilla adapted for egg laying. Behaviorally, males tend to be more aggressive and territorial, while females are more involved in nest preparation and egg care.

#### **1.4 Mating behavior and breeding**

Captive breeding of *Astronotus ocellatus* involves systematic stages, including broodstock selection, sex identification, spawning, and larval rearing. The species forms monogamous pairs and may spawn 3-4 times annually (Rocha, 2025). Pair formation is indicated by characteristic behaviors such as tail slapping, lip-locking, and joint cleaning of a flat spawning surface. Spawning occurs on cleaned substrates such as rocks, driftwood, or artificial plates. Female fecundity ranges from 1,000 to 2,000 eggs per clutch, followed by external fertilization by the male, who actively guards the nest (Rocha, 2025). Fertilized eggs are yellowish, demersal, adhesive, fragile, and slightly oval in shape (Paes et al., 2012). Hatching occurs within 46-58 hours at approximately 27 °C. Both parents provide care to the larvae and fry. Once the fry become free-swimming, they can be fed *Artemia* nauplii or finely ground commercial feed. Fry should be separated from adults when parental care declines to prevent cannibalism.

## 2. Breeding of Discus fish (*Symphysodon* spp.)



### 2.1 Origin and varieties

Discus fish (*Symphysodon* spp.) are native to the Amazon River basin of South America, particularly in Brazil, Peru, and Colombia. They inhabit slow-moving, warm, soft, and slightly acidic waters with submerged roots and dense vegetation. In captivity, discus require well maintained tanks with stable water quality, a temperature of 28-30 °C, pH 5.5-6.8, gentle filtration, and a stress-free environment. Discus are among the most valued ornamental fishes in the global aquarium trade due to their vibrant colors, unique patterns, and graceful appearance, resulting in high market demand and premium pricing. Adults typically reach 15-20 cm in diameter. Popular varieties include Blue Discus, Red Discus, Turquoise Discus, Pigeon Blood Discus, Marlboro Red, Leopard Discus, and Albino Discus.

### 2.2 Broodstock conditioning and nutritional requirement

Broodstock conditioning of discu is crucial for successful spawning and involves maintaining healthy, mature pairs under optimal environmental conditions. Conditioning tanks should have stable water quality, soft and slightly acidic water (pH 5.5-6.5), and a temperature of 28-30 °C. Broodstock should be fed a high-quality, nutritionally balanced diet rich in protein (45-50%), consisting of premium pellets supplemented with live or frozen feeds such as bloodworms, brine shrimp, and beef heart. Adequate levels of essential fatty acids, vitamins (especially vitamins C and E), and minerals are necessary to enhance gonadal development,

fecundity, and egg quality. Dietary supplementation with probiotics and natural color enhancers further supports brood health, immunity, and reproductive performance.

### **2.3 Sexual dimorphism of discus fish**

Discus fish exhibit very limited sexual dimorphism, making external sex identification difficult, especially outside the breeding period. Males are generally slightly larger with a more pointed dorsal and anal fin extension, while females tend to have a rounder body shape. During spawning, the most reliable distinction is the genital papilla: males display a small, pointed breeding tube, whereas females exhibit a larger, rounded ovipositor. Behavioral cues such as increased aggression and territory defense are more common in males, while females are more actively involved in egg laying and initial egg care.

### **2.4 Mating behavior and breeding**

Discus fishes form strong monogamous pairs and exhibit distinct mating behaviors prior to spawning. Courtship includes mutual swimming, fin flaring, lip-locking, and cleaning of a vertical spawning surface such as a cone or tank wall. Spawning occurs when the female lays 200-400 adhesive eggs on the cleaned surface, followed by external fertilization by the male. Both parents guard and fan the eggs, which hatch within 48-60 hours at 28-30 °C. After becoming free-swimming, the fry initially feed on mucus secretions from the parents' skin before being weaned onto *Artemia nauplii* and fine commercial feeds.

### 3. Breeding of Loaches (*Botia* spp.)



#### 3.1 Origin and varieties

Loaches are native to freshwater systems of South and Southeast Asia, particularly India, China, Thailand, Indonesia, and Myanmar, where they inhabit slow to moderate flowing rivers, streams, and floodplains. In aquaria, they prefer well-oxygenated water, gentle to moderate current, temperatures of 22-28°C, pH 6.0-7.5, sandy or fine gravel substrate, and plenty of hiding places such as rocks, driftwood, and plants. Loaches are highly popular in the ornamental fish trade due to their unique body patterns, active behavior, and utility as bottom dwellers, resulting in steady international market demand. Adult size varies by species, ranging from 6-10 cm in smaller loaches to 20-30 cm in larger species. Common ornamental varieties include Clown Loach (*Chromobotia macracanthus*), Zebra Loach (*Botia striata*), Yoyo Loach (*Botia almorhae*), Kuhli Loach (*Pangio* spp.), and Weather Loach (*Misgurnus anguillicaudatus*).

#### 3.2 Broodstock conditioning and nutritional requirement

Broodstock conditioning involves maintaining healthy adults under stable water quality with seasonal temperature cues and high dissolved oxygen. A protein-rich diet (40-45%) is essential, comprising quality sinking pellets supplemented with live or frozen feeds such as tubifex, bloodworms, earthworms, and insect larvae. Adequate essential fatty acids, vitamins, and minerals support gonadal maturation and spawning success.

#### 3.3 Sexual dimorphism

Sexual dimorphism in loaches is generally subtle. Males are often slimmer, with more pointed pectoral fins or slightly brighter coloration, while females are deeper-bodied, especially when gravid. In some species, males possess thickened pectoral fin rays or small tubercles during the breeding season.

The most definitive secondary sexual characteristic in the family Cobitidae is the presence of the lamina circularis, or Canestrini's organ. This structure is an ossified, scale-like bony plate found at the base of the second pectoral fin ray in mature males. The morphology of the *lamina circularis* whether axe-shaped, circular, or rectangular serves as a primary diagnostic tool for species identification and sexing. Beyond this bony plate, the pectoral fins of males are often more triangular and rigid, whereas females possess shorter, more rounded fins. These modifications are believed to assist the male in maintaining a firm grip or positioning during the vigorous, high-energy "chase" sequences that precede fertilization.

In the families Nemacheilidae (stone loaches) and Gastromyzontidae (hillstream loaches), dimorphism extends to specialized dermal structures and cephalic features. Males of many *Schistura spp* develop a suborbital flap or groove located just below the eye, which is either absent or significantly vestigial in females. Among hillstream loaches, such as the genus *Sewellia*, sexual dimorphism is visible in the dorsal profile and fin texture. Males exhibit a more "squared-off" snout and develop rows of hypertrophied tubercles, often referred to as "fences," along the leading edges of their pectoral fins. These tubercles provide the necessary friction for the male to remain attached to the female or the substrate in the rapid, turbulent waters they inhabit.

Further subtle distinctions are observed in the caudal morphology of the family Botiidae, most notably in the clown loach (*Chromobotia macracanthus*). In this species, the tips of the caudal fin in males tend to curve slightly inward toward the midline, creating a pincer-like silhouette, while the caudal tips of females remain straight. Additionally, during the peak of the breeding season, many loach species exhibit temporary changes in skin texture; males may develop fine "nuptial tubercles" on the head and body. These structures are not merely for display but serve a mechanical purpose, allowing for tactile stimulation and ensuring that the pair remains in close proximity during the broadcast spawning process.

### **3.4 Mating behavior and breeding**

Loaches exhibit increased activity and courtship during the breeding season, often stimulated by temperature changes and increased water flow. Courtship includes chasing and synchronized swimming. Most loaches are egg scatterers, releasing non-adhesive eggs that settle among substrates or vegetation. Fecundity of the fish is highly species specific which ranges from 500-11000. Fertilization is external, and parental care is usually absent. Eggs hatch within 24-72 hours depending on species and temperature, and larvae initially feed on yolk reserves before being offered infusoria and later *Artemia* nauplii.

#### 4. Breeding of Red-tailed black shark (*Epalzeorhynchus bicolor*)



##### 4.1 Origin and varieties

The red-tailed black shark (*Epalzeorhynchus bicolor*) is native to the Chao Phraya River basin of Thailand, where it inhabits rivers and floodplain habitats with moderate water flow. In captivity, it requires spacious aquaria with good filtration, high dissolved oxygen, temperatures of 24-28°C, and slightly acidic to neutral water (pH 6.5-7.5). A sandy or fine-gravel substrate with rocks, driftwood, and hiding spaces is essential for its survival. Due to its striking black body and bright red caudal fin, the species is highly popular in the global ornamental fish trade and commands consistent market demand. Adults typically reach 12-15 cm in length. Apart from the standard red-tailed shark, albino and color-enhanced forms are occasionally available in the trade.

##### 4.2 Broodstock conditioning and nutritional requirement

Broodstock conditioning requires maintaining healthy adults in large tanks or ponds with stable water quality and seasonal environmental cues. A balanced diet containing 35-40 % protein is recommended, comprising high-quality sinking pellets supplemented with algae wafers, blanched vegetables, and occasional live or frozen feeds such as bloodworms. Adequate vitamins, minerals, and essential fatty acids support gonadal development and spawning readiness.

##### 4.3 Sexual dimorphism

Sexual dimorphism in the Red-tailed Black Shark (*E. bicolor*), a critically endangered cyprinid endemic to Thailand and sexual dimorphism clearly visible after it attains 10-12 cm in length (age 1.5+ years). From a morphological perspective, the most reliable diagnostic feature for sex differentiation is the overall body profile and abdominal distension. The mature females exhibit more robust and convex ventral region, a physiological transformation for carrying oocytes which make them appear broader and heavier than their male counterparts. Comparatively, males are having a slender, more fusiform body shape which reflects a metabolic focus on agility and territorial defense compared to reproductive biomass. Beyond primary body mass, secondary sexual characteristics can be observed in the morphology of the fins, particularly the dorsal fin. The sexually mature males are having a posterior edge of the dorsal fin which frequently terminates in a more elongated point but in females, this distal margin appears more rounded or blunt. During the spawning season, the intensity of the caudal red colouration in males may increase due to hormonal surges, whereas gravid females may appear slightly duller or more charcoal-grey as their energy reserves are diverted toward vitellogenesis.

#### **4.4 Mating behavior and breeding**

Behaviorally, *E. bicolor* is known for high levels of intra-specific aggression, but the expression of this territoriality differs between the sexes. Males are characterized by heightened agonistic behavior, frequently engaging in lateral displays and chasing to establish dominance over specific micro-habitats. Females, being territorial, exhibit these behaviors primarily when resources are scarce or during reproductive competition. The species is an egg scatterer with external fertilization and shows no parental care. Eggs hatch within 10-24 hours, and larvae begin feeding on infusoria followed by *Artemia* nauplii and fine commercial feeds.

## 5. Breeding of Killifish (*Aplocheilus* sp)



### 5.1 Origin and varieties

Killifishes are widely distributed across Africa, South America, and parts of Asia, inhabiting streams, swamps, floodplains, and seasonal pools. They belong to the order Cyprinodontiformes and primarily categorized into two ecological groups i.e. annuals, which inhabit ephemeral rain pools in Africa and South America, and non-annuals, which reside in permanent bodies of water such as streams and swamps. In the global aquarium market, demand remains robust due to their vibrant jewel-like coloration and compact size. Popular varieties include *Aphyosemion*, *Fundulopanchax*, *Nothobranchius* (annual killifish), *Austrolebias*, and *Rivulus* species.

### 5.2 Broodstock conditioning and nutritional requirement

Successful reproduction relies upon scientific nutritional conditioning of the broodstock. To maximize fecundity and ensure high egg viability, breeders often separate males and females for a period of 7 to 14 days prior to spawning. During this window, the fish are fed a diet rich in proteins and lipids. Live foods are preferred over processed flakes, as they trigger the predatory instincts and hormonal responses necessary for gamete production. Essential dietary components include *Artemia salina* (brine shrimp), *Daphnia*, mosquito larvae, and white worms. For annual species, high-quality nutrition is especially vital, as their rapid metabolism and short lifespans demand constant caloric intake to sustain continuous egg production.

The conditioning of killifish requires a controlled environment that mimics their specialized natural habitats. Most species thrive in soft, slightly acidic water with a \$pH\$ ranging from 6.0 to 7.0 and temperatures maintained between 22°C and 25°C. Because many species originate from stagnant or slow-moving waters, they are sensitive to high-flow filtration; sponge filters are the preferred standard for providing biological filtration without excessive turbulence. Tank décor should include dense vegetation, such as Java moss or floating plants, to provide refuge and reduce inter-species aggression. A critical aspect of their husbandry is the requirement for a secure, tight-fitting lid, as their physiological adaptation for jumping between small pools makes them highly prone to escaping open-topped enclosures.

### **5.3 Sexual dimorphism**

Adult killifishes are generally small-bodied, with most species ranging from 2.5 cm to 10 cm in total length. They exhibit extreme sexual dichromatism and dimorphism, making gender identification straightforward once they reach maturity. Males typically display an array of iridescent pigments, including metallic blues, deep reds, and oranges, often complemented by elongated dorsal and anal fins or ornate "lyre-tail" caudal structures. Conversely, females are characterized by cryptic coloration with shades of olive, beige, or silver and possess shorter, rounded fins. This lack of ornamentation in females serves as an evolutionary defense against predation, while the male's flamboyant appearance is a primary driver of female mate selection.

### **5.4 Mating behavior and breeding**

The mating behavior of killifishes is characterized by a synchronized "side-by-side" display. The male typically courts the female by flaring his fins and guiding her toward a suitable spawning substrate. Upon acceptance, the pair assumes a J-shape posture, pressing their bodies together to facilitate the simultaneous release and fertilization of eggs. Breeding strategies vary by ecological group: non-annuals are generally mop spawners, depositing adhesive eggs onto submerged plants or synthetic acrylic mops. Annual species are "substrate divers," burying their eggs deep into the mud or peat at the bottom of the pool. In a laboratory or breeding setting, this peat is harvested and stored in a semi-dry state for several months to simulate the natural drought period required for the embryos to develop.

The fecundity of killifishes varies significantly between ecological groups, primarily driven by their disparate life expectancies and environmental stability. Annual species, such as those in the genus *Nothobranchius*, exhibit high daily fecundity to compensate for their extremely compressed lifespans; under optimal nutritional regimes, a single female can produce between 30 and 50 eggs per day. In contrast, non-annual species typically exhibit lower, more sporadic reproductive output, often depositing smaller clutches of 10 to 30 eggs weekly depending on the species and environmental cues.

## 6 Breeding of high-value bicolour and tricolour goldfish (*Carassius auratus*)



### 6.1 Origin and varieties

The bicolour and tricolour goldfishes (*Carassius auratus*) are good examples of selective breeding procedure to develop high value and attractive fishes. These goldfishes are identified with combination of 2 or more colours including red, black, white, gold and mosaic. These varieties originated in ancient China, later refined by Japanese breeders. Unlike their wild ancestor, the Prussian Carp, which inhabits sluggish, murky freshwater, these fancy variants are strictly human developed. In current scenario, demand for these fishes remains exceptionally high in international market, particularly in Southeast Asia, Europe, and North America. Tricolour variants like the Azuma Nishiki or Calico Oranda fetch premium prices due to their unique, non-repeating patterns.

### 6.2 Broodstock conditioning and nutritional requirement

The broodstock conditioning of goldfish is aimed to maximize the fecundity and gamete quality of broodstock. The method typically spans between 4 to 8 weeks, during which males and females are separately stocked in tanks to prevent premature spawning. Environmental manipulation may be implemented through gradual increase in the photoperiod to 12-14 hours and a strategic rise in water temperature to simulate the onset of spawning. Through proper conditioning the females may achieve optimal oocyte maturation and it help in stimulating high density milt in males, reducing the chances of poor fertilization rates during the spawning event.

Water temperature serves as the primary metabolic catalyst for goldfish reproduction. While goldfish are eurythermal and can survive across a wide range, the ideal window for gonadal development is 20°C to 24°C. To trigger active spawning behavior, the temperature is often modulated upward to 25°C or 26°C. Maintaining thermal stability is critical, as fluctuations exceeding 2°C within a 24 hour period can induce physiological stress, leading to egg re-absorption or atresia in females. It may also lead to reduced sperm motility in males. In intensive stocking, chillers and heat exchangers may be employed to unlock the optimal threshold level of breeding.

The habitat and nutritional requirements during broodstock conditioning should be strictly followed to fulfill the nutritional demand of broodstock, therefore enhancing egg or sperm quality. The conditioning tank should be enriched with spawning substrates, such as synthetic breeding mops or aquatic macrophytes like *Ceratophyllum* sp, to promote the surface attachment of adhesive eggs. Nutritionally, a protein sparing strategy should be adopted to minimize the cost of feed and water pollution. The diets containing 35-40% crude protein and 8-10% lipid is optimal for goldfishes. Supplementation with live or frozen feeds like artemia nauplii or chironomid larvae (bloodworms), is essential for providing the essential fatty acids (HUFA) and amino acids required for vitellogenesis. In tank based systems, 10-20% water should be exchanged for promoting better culture environment or stocking in RAS or Biofloc based systems is highly beneficial for conditioning of broodstock.

### **6.3 Sexual dimorphism**

In goldfish, sexual dimorphism is not visible in juveniles and remains elusive even in adults. Differentiation is most defined during breeding season, when hormonal shifts trigger physical changes

#### **Year-round morphological Indicators**

- The body shape in the mature female are having a deeper and more rounded profile which is evident when inspected from above; the female will appear asymmetrical or swollen on one side in case of gravid or egg carrying stage. The males tend to be more slender and streamlined.

- The anal vent in female is typically round and convex and during breeding phase it becomes more prominent and reddened. In case of female, the anal vent is usually smaller, oval-shaped, and concave.
- The pectoral fin in male is generally thicker and sturdier compared to the finer, more tapered fins of the female.

### **Seasonal indicators**

- Breeding Tubercles or nuptial tubercles is one of the reliable sign of a male goldfish during breeding season. Males develop small, white, salt-like bumps called tubercles on their gill covers (operculum) and along the leading edges of their pectoral fins. These tubercles are symmetrical and organized in rows.
- The abdominal area of female is generally soft and pliable but in male abdomen remains significantly firmer.

### **6.4 Mating behavior and breeding**

Once physiological readiness is achieved, the male and female fishes were stocked at 2:1-3:1 ratio. During the physiological readiness, courtship behavior is observed through a vigorous behavioral display known as driving. During this phase, male exhibit heightened agonistic and sexual energy, relentlessly pursuing the female and they use their nuptial tubercles to nudge the abdomen of and flanks. This persistent contact is not only ritualistic; it also provides the tactile stimulation necessary for the female to oviposit. The climax occurs when the female shifts toward aquatic vegetation or synthetic spawning mops, releasing batches of adhesive, demersal eggs that the male simultaneously fertilizes. This synchronized quivering behavior ensures that the sperm makes immediate contact with the egg membrane before the micropyle (the entry point for sperm) closes upon water hardening. Fecundity of the well matured and conditioned female (2-4 years) ranges between 1000-10000 numbers in one breeding season. The eggs incubate within 36-48 hours at 25-28°C. Proper care should be taken for the eggs to prevent fungal infection. Parents should also be removed from tanks to eliminate the chances of egg eating.

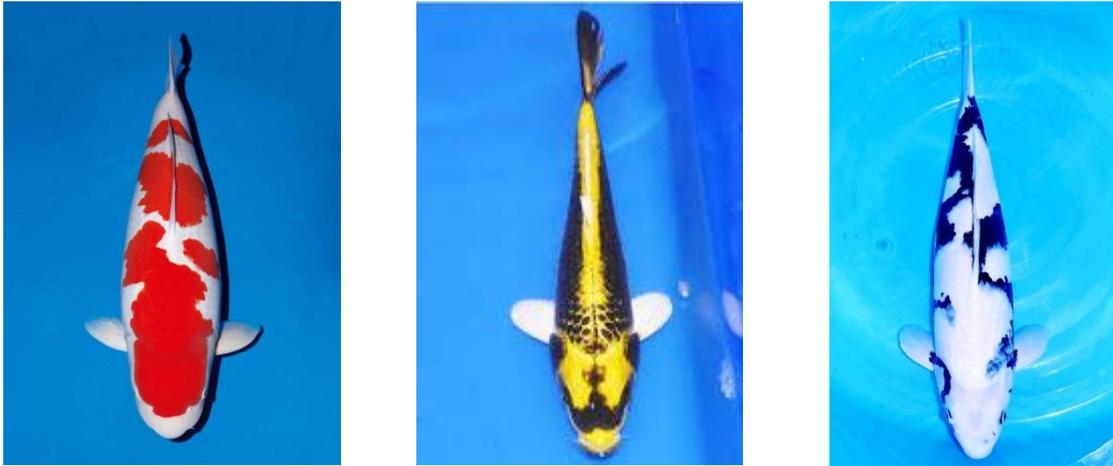
Post-spawning management is critical for maximizing the hatching rate, as goldfish lack parental care and actively consume their own ova if not separated. The eggs, which are

approximately 1.2 to 1.5 mm in diameter, are highly sensitive to fungal pathogens like *Saprolegnia* spp, especially those that remain unfertilized and turn opaque. In professional hatcheries, the spawning substrate is often moved to specialized incubation tanks where the water is treated with mild prophylactic agents like methylene blue or  $KmnO_4$  at 10-15 ppm dosage. Over the next 72 to 96 hours, the embryos undergo rapid organogenesis, visible through the development of eye spots within the transparent casing, eventually hatching into pro larvae that rely on their yolk sacs before transitioning to external feeding.

Larval rearing is the most critical phase in goldfish production, demanding a transition from endogenous to exogenous nutrition. For the first 48-72 hours post hatching, the pro larvae remain in a stationary yolk-sac phase, adhering to surfaces and absorbing nutrients from their yolk. During this window, external feeding is avoided to prevent water spoilage. Once the yolk is absorbed, the fry enters the swim up stage, inflating their swim bladders and requiring immediate microscopic feed. Initial feeding involves infusoria or finely strained egg yolk, quickly transitioning to live *Artemia* nauplii (brine shrimp) within a few days. The predatory movement of live feed is essential for stimulating the fry's hunting reflex and providing the high protein (45-50%) required for rapid morphogenesis.



## 7. Breeding of high-value koi carp (*Cyprinus rubrofuscus*)



Koi carp (*Cyprinus rubrofuscus*), often referred to as living jewels, are a domesticated ornamental subspecies of the common carp. Unlike goldfish, they are known for their massive size, intelligence, and longevity. Kohaku, Tancho, Kabutai are few of the important varieties of Koi carps which are highly demanding in national market.

### 7.1 Origin and varieties

The lineage of Koi carp traces back to central Asia, from where they were introduced to China and eventually Japan where various varieties were developed through selective breeding. The Japanese, specifically in the Niigata Prefecture during the early 19th century, began selectively breeding them for their unique color mutations. Unlike their wild ancestors that inhabit the murky, slow-moving waters of rivers and lakes across Eurasia, modern Koi are raised in specialized mud ponds or tanks. Intensified culture requires scientific intervention through RAS and biofloc based systems. They are hardy and eurythermal animal, meaning they can survive in wide range of temperatures ranging from near freezing to 35°C, though they thrive best in temperate freshwater environments with high dissolved oxygen.

### 7.2 Broodstock conditioning and nutritional requirement

Broodstock conditioning is the specialized process of preparing mature Koi for spawning by optimizing their physiological health and gamete quality. This phase typically begins in late winter or early spring, as water temperatures begin to rise. In a controlled aquaculture like

tanks, RAS or biofloc based systems conditioning allows breeders to manipulate environmental cues to synchronize the spawning of high-value pairs.

The conditioning process involves a gradual transition in water parameters. To simulate the natural onset of the breeding season, the water temperature is slowly increased to a stable range of 18°C to 22°C. During this time, optimum water quality is required; nitrogenous wastes like ammonia and nitrite must be kept at zero to prevent stress induced egg re-absorption (atresia). Separation of sexes during this period is a common practice among professional breeders to prevent accidental spawning and to allow for targeted nutritional flushing of the females.

Nutrition is the most critical factor during conditioning, as the quality of eggs and larvae completely depends on ideal nutrition. To ensure high quality egg and milt, the protein content of the diet should be optimum to 40-45%. It is essential that this protein is sourced from high quality ingredients from marine source (like fish meal or krill meal) which contain the full profile of essential amino acids required for embryonic development. The lipid content should be ranged between 8-12%. Specifically, highly unsaturated fatty acids (HUFAs) such as EPA and DHA are vital. These fats are incorporated into the egg yolk and directly influence the hatching rate and the vigor of the newly hatched fry. The vitamin and minerals should be fortified in feed for better result. Increased levels of Vitamin E and Vitamin C act as potent antioxidants, protecting the developing gametes from oxidative stress and improving the fertility rates of the males. Live and fresh Supplements of live or fresh frozen foods like Chironomid larvae (bloodworms) or chopped earthworms should be incorporated which provides a hormonal boost. Carotenoids like astaxanthin should also be supplemented during conditioning which ensures a baseline of pigment and antioxidant supplementation from early stages improving their early-stage survival.

### **7.3 Sexual dimorphism**

In Koi carp, sexual dimorphism is not immediately apparent in juvenile fish. Distinguishing between males and females generally becomes reliable once the fish reach sexual maturity, typically between 2 to 3 years of age, or when they exceed 10-12 inches (25-30 cm) in length.

Feature	Male	Female
<b>Body Shape</b>	Slender & Torpedo-like: Maintains a streamlined profile from head to tail; lacks significant girth.	Round & Robust: Broad abdomen; appears bottom-heavy or swollen when gravid (carrying eggs).
<b>Pectoral Fins</b>	Pointed & Opaque: Larger in proportion to the body; often solid in color with a thick leading ray.	Rounded & Translucent: Edges are blunt or circular; fins appear more delicate and clear.
<b>Breeding Tubercles</b>	Present: Small, white, sandpaper-like bumps appear on gill covers and pectoral fins during spring.	Absent: Skin remains smooth on the operculum and fins throughout the year.
<b>Vent Anatomy</b>	Oval & Concave: The opening is elongated and typically flush with the body or slightly indented.	Round & Convex: The opening is circular and protruding; may become swollen or pink during spawning.
<b>Top-Down View</b>	Symmetrical: Minimal variation in width across the body length.	Asymmetrical: Noticeable widening in the midsection, especially during the breeding season.
<b>Tactile Feel</b>	Rough: Feels like fine sandpaper on the head and fins during the breeding season.	Smooth/Soft: The body feels pliable and soft, especially around the abdominal region.
<b>Behaviour</b>	Aggressor: Relentlessly chases, nudges, and drives other fish during spawning.	Passive: Becomes the target of chasing; seeks cover or vegetation to deposit eggs.

#### 7.4 Mating behavior and breeding

The mating and spawning of Koi carp is a synchronized biological event which combines proper conditioning, nutritional and environmental intervention.

Spawning is primarily governed by a combination of thermal and photoperiodic shifts. At a water temperature of 18°C and 22°C, the Koi's endocrine system triggers the final maturation of gametes. A large infusion of fresh, cool rainwater or a significant manual water change acts a catalyst for breeding. This phenomenon helps in environmental manipulation through increasing dissolved oxygen and providing the freshness required to

initiate the reproductive cycle. For breeding of koi carps the male: female ratio should be 2:1 to 3:1. Ideal koi carps should be 2-4 years old having atleast 10-12 inch total length.

The mating ritual, commonly referred as driving, usually begins in the predawn and can last for several hours. During this phase, the behavior becomes quite vigorous and even aggressive. One or more males will relentlessly pursue a gravid female, using their heads to nudge and bump her abdomen and flanks. This physical contact is essential; the pressure applied by the snouts and the tactile stimulation from their nuptial tubercles encourage the female to release eggs. The chase often involves high speed bursts and splashing as the males attempt to corner the female in shallow areas or thick vegetation. The climax of the mating behavior occurs when the female finally moves into dense aquatic plants or synthetic spawning brushes to deposit her eggs. In a rhythmic, quivering motion, a cloud of adhesive eggs were released. Simultaneously, the trailing males release milt directly over the eggs.

The eggs are demersal and adhesive in nature, meaning they sink and immediately stick to the first surface they touch to prevent being washed away by currents. Koi carps are exceptionally prolific spawners. A single mature female can produce between 100,000 and 500,000 eggs depending on her body weight (averaging about 100,000 eggs per kilogram of weight). The eggs are small, approximately 1.5 mm to 2.0 mm in diameter, and appear as clear or pale yellow translucent spheres. Healthy fertilized eggs remain clear, while unfertilized eggs turn an opaque white within 24 hours and often become hosts for fungal growth. Attention should be given to prevent fungal infections where prophylactics like methylene blue or  $\text{KmnO}_4$  should be applied at a recommended dosage of 10-15 ppm.

Once spawning is complete, it is a standard aquaculture practice to remove the broodstock or the spawning media to a separate tank, as Koi carps actively consume their own eggs. The incubation period is temperature dependent; at 20°C-23°C, the embryos will develop and hatch in 3 to 5 days. During this time, high levels of dissolved oxygen and a gentle water flow are necessary to prevent the accumulation of metabolic waste around the adhesive egg clusters.

## 8. Breeding of freshwater ornamental shrimps (*Caridina sp*)



The freshwater ornamental shrimps from the genus *Caridina sp* comprises some of the most popular freshwater ornamental shrimp in the hobby, most notable species include Bee Shrimp, Crystal Shrimp, and Amano Shrimp. These decapod crustaceans are prized for their specialized algae eating habits and striking color patterns.

### 8.1 Origin and Varieties

*Caridina spp* are primarily native to subtropical and tropical regions of Southeast Asia, particularly Southern China, Japan, Taiwan, and Vietnam. Unlike the hardier variety *Neocaridina sp* (Cherry Shrimp), *Caridina spp* originated from oxygen saturated cooler mountain streams. Some popular varieties under this genus include *Caridina logemanni* (Bee Shrimp), having a diverse crystal Red (CRS) and crystal Black (CBS) colouration. Other notable species include *Caridina multidentata* (Amano Shrimp), known for its size and algae-consuming prowess, and the Cardinal Shrimp (*Caridina dennerli*) which is first reported from the ancient lakes of Sulawesi.

### 8.2 Habitat and ideal water quality

In the wild, these shrimp inhabit clean, soft-water streams with rocky or sandy bottoms and abundant leaf litter. In captivity, they are sensitive to water quality and require specific parameters to thrive and molt successfully. They prefer a slightly acidic pH (6.0-6.8) and soft water with a low carbonate hardness and TDS ranged between 100-200 ppm. They are highly sensitive to nitrate and copper, therefore a well cycled tank with active substrate (which buffers pH) and mosses like java moss or fission is essential for their habitat.

### 8.3 Nutritional Requirements

For growth and successful molting, *Caridina* shrimp require a diet rich in vegetable matter but supplemented with protein and minerals. In vegetable matter a high intake of spirulina and spinach provides essential vitamins. Though protein is highly required for its growth, but excessive animal protein can cause molting issues commonly known as white ring of death. Optimum crude protein requirement for this species is 30-35%. Minerals specifically calcium and magnesium is vital for moulting and formation of new exoskeleton. Other than these carotenoids like astaxanthin is essential for maintaining the vibrant red and orange pigments in many high-grade varieties.

#### **8.4 Broodstock conditioning**

The broodstock conditioning of freshwater ornamental shrimp like *Caridina* sp., focuses on stabilizing environmental parameters and providing specific nutrients to ensure the female successfully develops a "saddle" (ovaries filled with unfertilized eggs) and undergoes a healthy molt. For ideal conditioning the broodstock should be kept at ideal water quality with pH range of 6.0–6.8, hardness at 150-200 ppm and temperature at 22-24°C. The variety is highly sensitive to fungal infection which limits sudden water exchange. The stocking water should be well conditioned and aerated before stocking, The experienced breeders often apply cold water (1-2°C fluctuation) or nutrient-rich rainwater which act as a catalyst for the female to molt and release the pheromones necessary for mating.

Nutritional conditioning for *Caridina* broodstock centers on two main factors i.e. egg production and molting success. To develop high-quality saddles, high quality protein and lipid diet (Cyclops or formulated pellets) is necessary. Equally intake of calcium and magnesium is critical; without these minerals, females may suffer from stuck molts during the mating cycle, which is fatal to both the mother and the brood. Finally, a constant supply of natural biofilm is essential. Using powdered bacterial additives or Indian almond leaves ensure a 24-hour source of periphyton. This promotes continuous grazing and healthy digestion without fouling the water, ultimately leading to higher fecundity and healthier larvae.

## 8.5 Sexual dimorphism

Feature	Male	Female
<b>Body Size</b>	Generally smaller and more compact.	Noticeably larger and more robust.
<b>Body Shape</b>	Slender and streamlined (torpedo-like).	Broad and deep-bodied.
<b>Abdominal Profile</b>	Straight underbelly; lacks a "skirt."	Curved underbelly: Possesses a deep "skirt" (pleopods) to carry eggs.
<b>Color Intensity</b>	Often less intense; can be more translucent.	Usually more vibrant, opaque, and deeply pigmented.
<b>Ovaries (Saddle)</b>	Absent: No visible egg mass in the upper body.	Present: Visible "saddle" (unfertilized eggs) behind the head/neck area.
<b>Movement/Activity</b>	Highly active; dances (swims rapidly) when pheromones are present.	Generally more sedentary, focused on grazing and egg care.
<b>Pleopods (Swimmerets)</b>	Shorter and tucked closer to the body.	Longer and broader to facilitate egg fanning and protection.

## 8.6 Mating behavior and breeding

Breeding in *Caridina* sp is primarily triggered by the molting process of female, often stimulated by a fresh water change that mimics natural rainfall. Immediately after molting, the soft shell female releases pheromones in the water column, initiating a frantic breeding dance as male swim throughout the tank to locate her. Once mating occurs, the female becomes berried, carrying a clutch of 20 to 40 eggs tucked securely under her pleopods. These females reach sexual maturity between 3 to 5 months of age. Throughout the incubation period, of 28 to 35 days at a temperature of 22-25°C, the female constantly fans the eggs with her swimmerets to maintain high oxygen levels and prevent fungal growth. As hatching nears, the eggs change color and develop visible eye spots.

Post-hatching, most ornamental *Caridina* bypass the free-swimming larval stage and hatch as fully formed, miniature shrimplets. These tiny clones immediately begin grazing on their surroundings, but due to initial sedentary nature, the survival depends heavily on immediate availability of biofilm and microscopic algae. Breeders often use powdered bacterial supplements or micro-particulate diets to ensure food accessibility reducing excess energy wastage for the search of food.

## 9. Breeding of guppy (*Poecilia reticulata*)



The Guppy (*Poecilia reticulata*), commonly known as Millionfish is a prolific breeder which is one of the iconic species in the aquarium hobby. It started the journey from wild tropical streams and ends in high end aquaria through rapid evolution and curated selective breeding studies.

### 9.1 Origin and natural habitat

Guppy fish was first discovered in 1859 by Robert John Lechmere Guppy on the island of Trinidad. Due to his contribution for the species, the name is proposed. The fish was initially used by colonial authorities as a biological control for mosquitoes, as their larvae are a primary food source for wild guppies.

The Guppies are native to the Northeastern and South American region, with significant populations found in Trinidad and Tobago, Guyana, Suriname, and parts of Brazil and Venezuela. They are remarkably hardy extremophiles, capable of thriving in a vast range of habitats, from the oxygen rich, fast flowing mountain streams to murky, stagnant pools with low oxygen levels. This resilience is further evidenced by their impressive salinity tolerance; while primarily freshwater fish, they are frequently discovered in brackish water at river estuaries, demonstrating a unique ability to adapt to varying osmotic pressures. Socially, they are active shoaling fish that maintain a high-protein diet by foraging on algae, mineral particles, and various aquatic insects.

## 9.2 Common varieties

Category	Variety Name	Defining Characteristics
<b>Tail Shape</b>	Delta / Veil Tail	A broad, triangular caudal fin that creates a large surface area for color display.
	Double Swordtail	Features distinct, elongated rays extending from both the top and bottom edges of the tail.
	Lyretail	A unique shape resembling a lyre, where the outer edges curve outward and extend past the center.
	Pin / Spade Tail	The tail narrows into a singular, sharp point (Pin) or a rounded point (Spade).
<b>Patterns</b>	Cobra / Snakeskin	A complex, rosette or lace-like vertical pattern across the body and fins.
	Tuxedo	A bicolor contrast where the posterior half of the body is solid black or dark blue.
	Leopard / Mosaic	Features large, bold, irregular spotting on the tail and dorsal fins.
	Grass	Characterized by a dense "dusting" of very fine, tiny spots across the fins.
<b>Color Strains</b>	Solid Colors	Bred for total uniformity in a single hue, such as "Full Red" or Full Platinum.
	Albino	A genetic mutation resulting in a total lack of black pigment and striking red eyes.
	Metallic	Features iridescent guanophores that reflect light in shades of gold, silver, or green.

## 9.3 Broodstock conditioning and nutritional requirement

Conditioning guppy broodstock is the essential practice of preparing brooders for successful and high yield seed production. While guppies are naturally prolific, professional conditioning should focus on building the physical reserves to handle the intense strain of live bearing female. The conditioning process begins by separating males and females for a period of two to three weeks, allowing the females to direct all metabolic energy toward

ova development rather than going for constant courtship. During this phase, slight increase in the water temperature to 26°C-28°C to boost the metabolism of fish and perform frequent, small water changes to maintain pristine conditions, which signals a resource rich environment suitable for spawning.

Nutrition is the most critical factor of the conditioning process, requiring a shift from standard maintenance flakes to a diet rich in high quality proteins and lipids. Proteins, ideally comprising 45%-55% of the diet, are sourced from live or frozen foods like bloodworms and brine shrimp to ensure the production of viable sperm and robust egg membranes. Simultaneously, Highly Unsaturated Fatty Acids (HUFAs), specifically Omega-3 and Omega-6, must be supplemented. Beyond basic macronutrients, guppy broodstock require a complex array of vitamins and minerals to ensure reproductive success which includes vit E, vit D3 and calcium. Vitamin E acts as a vital anti sterility agent, while Vitamin D3 and Calcium are necessary for the skeletal development of the embryos carried by the female. Additionally, the inclusion of carotenoids like astaxanthin and plant-based matter such as spirulina serves a dual purpose i.e. i. it enhances the aesthetic coloration of the parents and ii. it provides powerful antioxidants that protect the developing embryos from oxidative stress. Focus should also be given on the methodology of feeding which is as important as the nutritional content itself. To maximize absorption and minimize waste, farmers should implement high feeding frequency ranging from 4-6 times/day. This intensive feeding cycle, when combined with a varied menu of live, frozen, and high-quality dry foods, ensures that the resulting fry are born with significant fat reserves, allowing them to grow faster and exhibit stronger immune systems from the moment they are born.

#### **9.4 Sexual dimorphism**

The physical differences between male and female guppies are completely pronounced that they are often mistaken as different species by beginners. Detailed sexual dimorphism criteria are as follows

<b>Feature Category</b>	<b>Physical Attribute</b>	<b>Male Characteristics</b>	<b>Female Characteristics</b>
<b>Primary Anatomy</b>	Anal Fin Structure	Modified into a thin, rod-like organ called the Gonopodium used for internal fertilization.	Maintains a natural, Fan-shaped or triangular appearance used for swimming stability.
	Gravid Spot	Completely absent.	Present; a dark triangular mark near the anal fin that indicates the location of the womb.
<b>Body Morphometrics</b>	Overall Size	Small and streamlined, typically reaching only 2.5-3.5 cm in length.	Significantly larger and deeper-bodied, reaching 5-6 cm in length.
	Body Shape	Slender and "torpedo-shaped" to allow for quick, agile courtship displays.	Robust and rounded, particularly in the abdominal area to accommodate developing fry.
<b>Colour and Pattern</b>	Body Coloration	Highly vivid with neon, metallic, or iridescent scales across the entire body.	Generally dull olive-green, silver, or grey to provide camouflage in the wild.
	Patterns	Covered in complex spots, stripes, or "snakeskin" patterns for sexual attraction.	Mostly plain, though modern "fancy" strains may show some color/pattern in the tail.
<b>Fin Morphology</b>	Dorsal & Caudal Fins	Usually elongated, flowing, and oversized.	Short, translucent, and rounded; designed for efficient movement rather than display.
<b>Behavioral Traits</b>	Social Interaction	Highly active; spends most of the time performing "S-shaped" courtship dances.	More passive; focused primarily on foraging and seeking cover.

## 9.5 Mating behavior and breeding

The mating ritual of guppies is a high energy display primarily driven by the male's need to prove his genetic fitness to a discerning female. To initiate breeding, the male performs a sigmoid display, arching the body into a distinct s-shape and vibrating fins with high intensity to showcase his colors and vitality. The female will respond with slower swimming to allow the male to approach. The guppy males are notoriously persistent and will often attempt sneak matings using a rapid gonopodial thrust if the female is occupied or non-responsive.

As ovoviviparous fish, guppies do not lay eggs in the traditional sense; instead, they undergo internal fertilization. Once the male transfers sperm via his gonopodium, the eggs are fertilized and held within the female's body. The incubation period often referred to as the gestation period typically lasts between 21 to 30 days. This duration is highly dependent on environmental factors, particularly water temperature and the stress levels of the female. During this time, the embryos develop inside the female, nourished by their yolk sacs, until they are ready to emerge as fully formed, free-swimming fry. This biological advantage enhances female ability to store sperm for several months, allowing her to produce multiple broods from a single mating encounter. The fecundity of guppy, is highly determined by the age, size, and nutritional health of the matured female. A young female on her first mating may produce a small brood of only 5 to 10 fry, but a mature, well-conditioned female can exhibit a fecundity of 60 to 100 fry in a single birth. During breeding, the female's abdomen shows on a boxy or squared-off appearance, and the gravid spot near her anal fin darkens significantly as the fry develop eyes. Because guppies do not provide parental care and may even cannibalize their young, the survival of the brood depends on the presence of dense vegetation where the newborn fry can instinctively hide.

The actual delivery of the fry, is commonly termed as "dropping," usually occurs over a period of one to six hours. The fry are born tail first or curled into a small ball, instantly unfurling and swimming toward the surface to fill their swim bladders with air. Because of their high fecundity and short incubation cycles, a single pair of guppies can result in hundreds of offspring within a few months. To ensure these fry reach maturity, breeders often provide natural substrates and plants like guppy grass coupled with specialized

nutritionally balanced food enriched in protein, as the newborns are immediately capable of eating and require high energy to avoid predators and grow into the next generation of breeders.

## Common varieties of commercially important fishes

### Oscar fish



**Copper Oscar**



**Tiger oscar**



**Mango Oscar**



**Albino oscar**



**Red chilli Oscar**

## Discus fish



Blue diamond discus



Red melon discus



Snakeskin discus



Heckel discus



Green discus

**Loaches**



**Y loach**



**Zebra loach**



**Tiger loach**



**Kuhli loach**



**Hill stream loach**

Freshwater ornamental shrimp (*Caridina* sp)



Crystal black shrimp



Crystal red shrimp



Blue bolt taiwanese shrimp



Amano shrimp

## Bicolour and tricolour goldfishes



**Bicolour lionhead oranda goldfish**



**Bicolour ranchu goldfish**



**Bicolour lionhead panda goldfish**



**Tricolour goldfish**



**ICAR-CENTRAL INSTITUTE OF FISHERIES EDUCATION**  
(University under Sec. 3 of UGC Act 1956)  
Panch Marg, Off Yari Road, Andheri (West), Mumbai – 40061

